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# The great stagnation and environmental sustainability: A multidimensional perspective

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## Abstract

Since the 2008/09 Great Financial Crisis, we have witnessed a prolonged period of persistent global economic slowdown termed the “Great Stagnation”. This study examines how this “new normal” is associated with critical environmental dynamics (i.e., biodiversity, water, forest, agriculture, emissions) in areas and groups with different socio-environmental characteristics (i.e., income groups, continents, forest cover, biome, environmental performance index). Mixed results are shown. For instance, we find a deterioration in terrestrial and marine biodiversity, especially in middle- and high-income countries in Africa and Europe. This includes a reduction in the global fish stock, driven by countries in Africa. In contrast, the Great Stagnation is associated with reductions in PM<sub>2.5</sub> (lower- and upper mid-income countries), CH<sub>4</sub> emissions (upper mid-income countries and Europe), forest loss (upper mid-income countries and Asia), and increases in species habitat index (across most groupings). Our evidence indicates that periods of economic slowdown, such as the great stagnation, on their own cannot ensure a transition to a sustainable socio-environmental system and may be associated with significant negative environmental effects. Managing our transition to sustainability will require concerted policy efforts across multiple environmental domains, not only on carbon emissions, and during periods of both strong and weak economic growth rates.

## KEYWORDS

biodiversity, biomes, degrowth, emissions, forest area, income groups, new normal

## 1 | INTRODUCTION

The rate of economic growth has a significant impact on environmental sustainability. High growth rates lead to the deterioration of environmental indicators (e.g., air and water quality, biodiversity) and dangerous climate change (Bowen & Stern, 2010; Dietz & Adger, 2003; McPherson & Nieswiadomy, 2005; Mills & Waite, 2009; Stern, 2006). Yet our socio-economic system is based on growth rates, and this growth-dependency has been intensified over the last decades, during which the global economy came to be based more

than ever before on credit expansion and debt (Antoniades & Griffith-Jones, 2018). In this context, “post-growth” has emerged as a new research programme aiming at exploring the possibility and conditions of transition to a different socio-economic system (for instance, Jackson, 2016; Kallis, 2018). Despite the diversity of approaches, the common ground here is that economic growth, as we know it today, needs to slow down (i.e., “degrowth”) (Cosme, Santos, & O'Neill, 2017; D'Alisa, Demaria, & Kallis, 2015; Martínez-Alier, Pascual, Vivien, & Zaccai, 2010; Schneider, Kallis, & Martínez-Alier, 2010), if environmental and planetary sustainability is to be restored.

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Yet, there is quantitative as well as qualitative evidence that slower economic growth, on its own, cannot ensure transition to a sustainable socio-environmental system. A recent study examined how episodes of economic slowdown (e.g., financial crises), over the last four decades, impact air quality (Pacca, Antonarakis, Schröder, & Antoniadis, 2020). The authors found that although the reduction in growth rates has a positive impact on the environment, this impact is short-lived, rather heterogeneous across different groups of countries, and disappears or turns negative 1–2 years after the beginning of these episodes (regardless of their duration). Qualitative evidence from case studies support these findings. For instance, studying the effect of the 1997 and 2008 financial crises in East Asia, Elliott (2011) finds that any positive environmental consequences were short-lived, while negative impacts endured. The latter include pressures for “further deforestation, agricultural expansion at the expense of water and soil quality, and lax enforcement of pollution regulations” (ibid. 179). Moreover, the priority for both government and the private sector in the post-crisis environment was investments that would generate “quick returns to compensate for losses rather than pursuing longer-term environmental and financial sustainability” (ibid. 180) (for a recent literature review see Pacca et al., 2020).

The above evidence is derived from episodes related to shock events, for instance abrupt economic slowdowns due to financial crises. Therefore, these findings are characterized by a “shock-bias”, i.e. they are derived from conditions that signify temporary, short-term diversions from a “normal” economic trend. This “shock-bias” is overcome by a different set of studies that are based on statistical modeling and computer-based simulation techniques. These studies attempt to assess how a prolonged period of growth slowdown or no growth will impact on environmental sustainability (e.g., Barrett, 2018; Hardt & O'Neill, 2017; Jackson & Victor, 2015). Yet, although these studies overcome the shock-bias, they bear the weaknesses associated with the attempt to model and project social reality.

Thus, existing empirical findings on the interplay between economic slowdown and environmental sustainability are coming either from past shock events or from future-oriented simulation studies. In this paper, we attempt to advance the state of the art in the existing

literature by adopting a rather different approach. The period after the 2008/09 Great Financial Crisis (GFC) has been characterized by a slow and fragile economic recovery. Despite very low interest rates and unprecedented liquidity support by Central Banks, growth rates have remained below their historical trend. This below-trend growth dynamics grew beyond the shadow of the GFC, acquiring characteristics of a “new normal” (El-Erian, 2009), defined by King (2019) as the period of “great stagnation.” This period thus provides a solid ground to examine the potential impact of a systemic economic slowdown on environmental sustainability at a global level.

In this context, this paper sets out to examine how this period of Great Stagnation is associated with key aspects of environmental sustainability at a global level. To do so, we examine 15 environmental indicators in 217 countries. We simultaneously consider six environmental categories: biodiversity, forest, water, agriculture, and atmospheric emissions. To explore potential determinants of the relationship, we adopt a five-dimensional clustering of countries that accounts for income-level, geographical position, environmental performance, forest cover, and dominant biome (see Table 1). To the best of our knowledge, this is the first paper that adopts such a comprehensive approach and reports non-simulated findings on how a prolonged period of economic slowdown has impacted on different aspects of environmental sustainability. For this reason, our approach is more exploratory rather than confirmatory. Our aim is to examine the relationship between our variables, allowing for a range of potential interlinking mechanisms that impact on environmental dynamics in periods of slower growth. Our results contribute to the post-growth literature (e.g., Jackson & Senker, 2011; Victor, 2012), by offering new evidence and insights that go beyond existing findings coming from “shock events” and simulation-based projections.

The paper is structured as follows. Section 2 reviews the literature on the link between the great stagnation and the natural environment. Section 3 describes our quantitative approach, the sources of the data, and the 15 environmental indicators considered. Section 4 presents the results and robustness checks. Sections 5 and 6 comprise a discussion of the main results, the empirical limitations, and the concluding remarks.

**TABLE 1** Number of countries per subgroup

Subgroup	Number of countries					
Income group	Global	Low	Lower-mid	Upper-mid	High	
	217	31	47	60	79	
Continent	Global	Americas	Asia	Africa	Europe	Oceania
	215	46	50	52	46	19
Environmental performance index	Global	Low	Lower-mid	Upper-mid	High	
	183	46	46	45	46	
Percentage of forest area	Global	Low	Mid	High		
	211	70	71	70		
Dominant biome	Global	Montane	Temperate	Tropical		
	216	29	79	107		

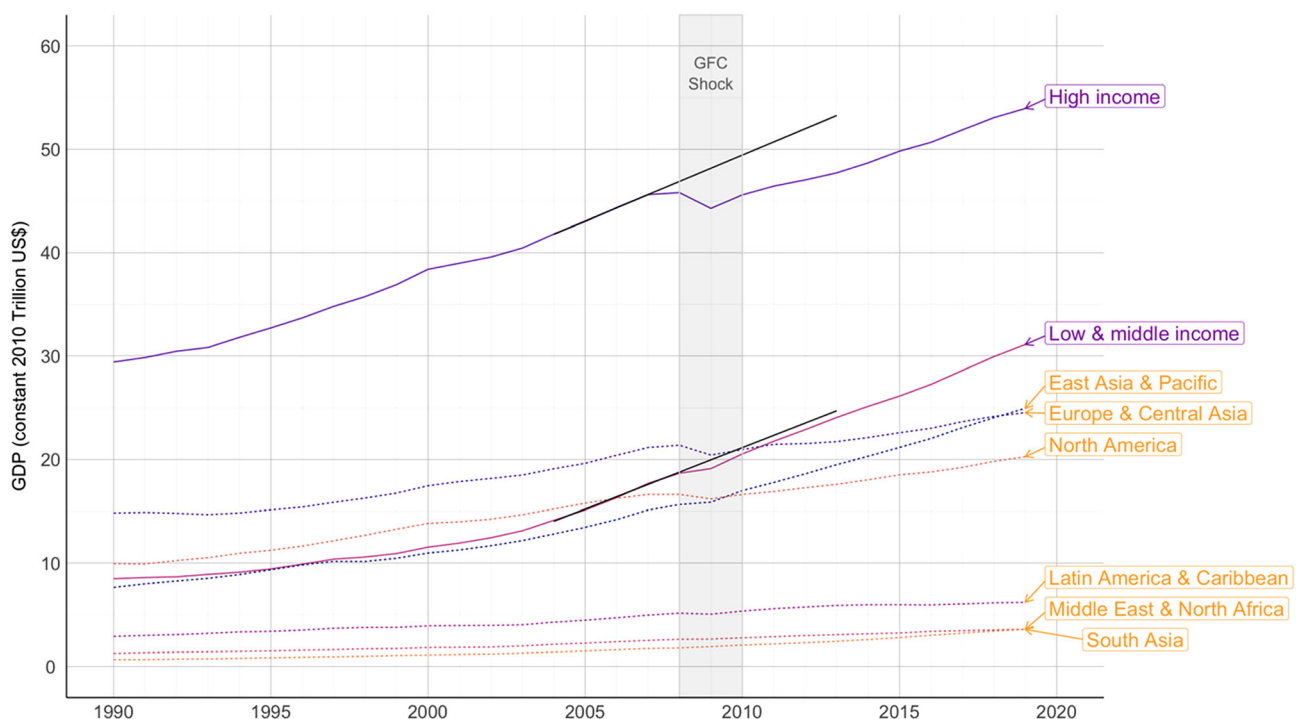
## 2 | THE LAST DECADE: THE GREAT STAGNATION AND NATURAL ENVIRONMENT

The global economic shock from the Great Financial Crisis proved more consequential than a temporary and reversible V-shaped disruption (i.e., featuring a sharp downturn and a rapid recovery). Advanced economies have been locked into a long-term low-growth trajectory, referred to as a “new normal” (El-Erian, 2009), “new mediocre” (Lagarde, 2014), “secular stagnation” (Summers, 2015) or the “great stagnation” (King, 2019). This trend does not only apply to advanced economies. As Figure 1 demonstrates a significant rupture in GDP trend is observable at global, high-income and middle-income countries levels. According to King (2019), “[t]he world economy is stuck in a low growth trap.”

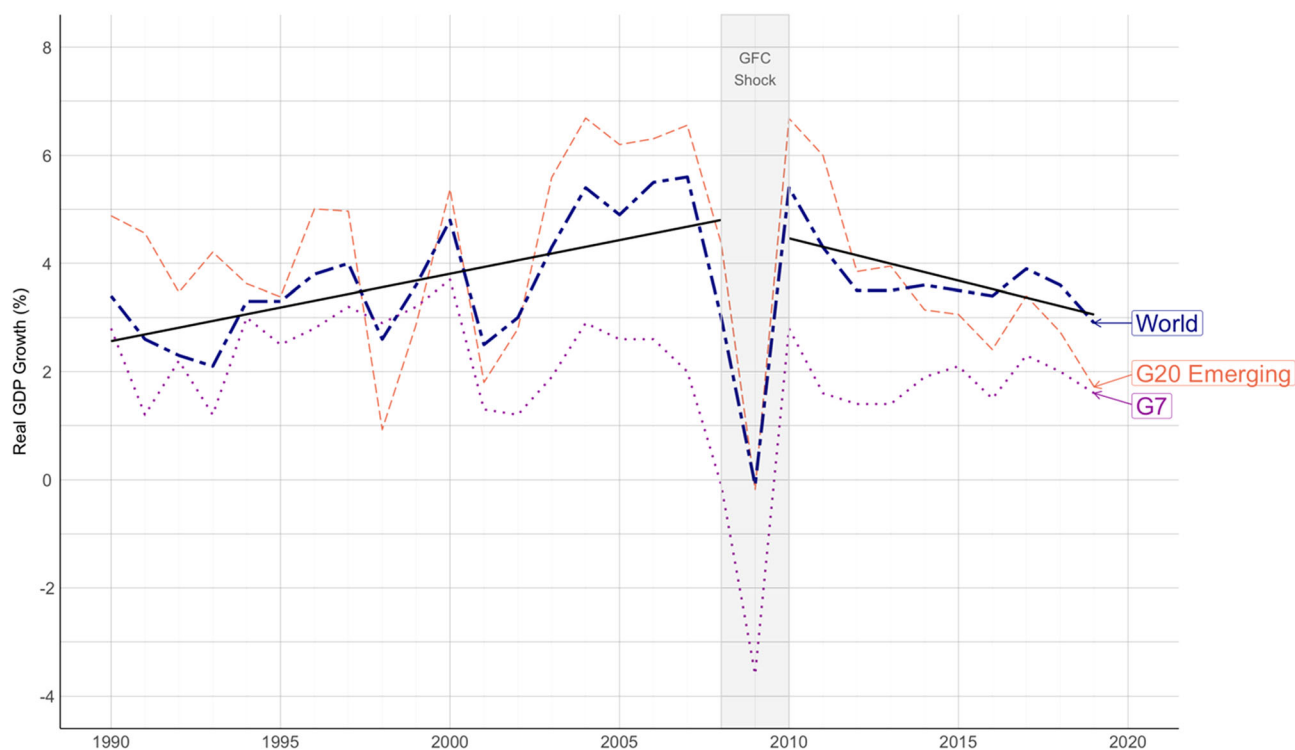
Prior to the GFC advanced economies grew by about 2.27% per year, whereas in the period since, it has averaged just 1.39% (IMF, 2020). The US, for example, experienced a growth of only around 1% yearly, significantly lower than the pre-crisis period of 3% GDP per capita between 1950 and 2000 (Haldane, 2015). Similar low growth rates occurred in several other advanced economies, which saw their average growth falling from 3.5% in the 1990s to 1.86% during 2010–2019 (IMF, 2020). Also, after the GFC, China, the second largest economy in the world, entered into a “new normal” of significant lower growth rates (see Appendix A in Table A1). The respective rupture in the global GDP trend is captured in Figure 2.

There is a growing consensus that economic growth at the current rate of depletion and degradation of environmental assets cannot continue indefinitely. Several scholars suggest that the economy needs to slow down (e.g., Jackson, 2016; Kallis, 2018). However, the existing literature offers inconclusive evidence on the environmental impact of slower economic growth. A number of studies have tried to predict what would be the impact of a period of sustained reduction of growth rates on the environment. Victor (2012) used macroeconomic scenario analysis to analyze the outcome of a period of degrowth in Canada and found positive social and environmental effects. In this scenario, greenhouse gas, unemployment, human poverty index, and debt to GDP ratio would be drastically reduced. Others have argued that degrowth would lead to potentially negative environmental and social impacts such as a shift in polluting activities (Van den Bergh, 2011). Pacca et al. (2020) argued that although the rate of economic growth is a key determinant for environmental sustainability, not all modes of degrowth lead to sustained positive environmental outcomes. Furthermore, studies using macroeconomic modelling have obtained mixed results when assessing distinct growth scenarios (Barrett, 2018; Hardt & O'Neill, 2017).

The uncertainty around the environmental outcomes of the great stagnation comes partly from the fact that we lack solid, robust evidence on the impact of economic slowdown on the environment. Existing models often overlook the multiple aspects of ecosystem or are based on a reduced representation of the socio-economic system (Hardt & O'Neill, 2017; Spash & Schandl, 2009). To increase our



**FIGURE 1** GDP (in constant 2010 USD) from 1990 to 2019 demonstrating the “great stagnation” rupture in 2008–2010 for Income Groups and selected World Regions. A linear trend fitted to the four years before the beginning of the great financial crisis (GFC) shown as black continuous line (source: World Bank, 2020) [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]



**FIGURE 2** Real GDP Growth, annual percentage change from 1990 to 2019. Two regression lines representing the average World GDP growth are plotted one from 1990 to 2008, and another from 2010 to 2019 (black continuous line) demonstrating a period of de-growth since the great financial crises (GFC) (source: IMF, 2020) [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]

understanding of the interplay between an economic slowdown and the natural environment, this study proposes an approach, which avoids the use of macroeconomic model assumptions by using a real example of stagnation period as our empirical test.

The literature surrounding the relationship between environmental quality and economic growth is extensive. The popular environmental Kuznets Curve, which argued that economic growth has an inverted U-shape relationship with environmental quality (Kuznets, 1955), no longer provides a relevant framework for this relationship (Stern, 2004) as it has been challenged by several empirical analyses (see Pacca et al., 2020). Although some data may suggest that wealthy countries seem to decrease their environmental impact over time, several potential externalities may hinder their behavior. For example, wealthy countries may reduce their domestic portion of materials extraction through international trade, while the overall mass of material consumption significantly increases (Wiedmann et al., 2015). Similarly, data on improving management of public waste disposal in wealthy countries do not take into account international waste trade (Cotta, 2020; Kellenberg, 2015).

On the other hand, there is a growing literature surrounding the effect of economic slowdown on environmental sustainability. Existing evidence suggests that environmental degradation tends to decrease straight after economic shocks occurs, but negative impacts endure (Elliott, 2011; Lekakis & Kousis, 2013; Pacca et al., 2020; Siddiqi, 2000). Endurance may be due to reinforced industrial activity and/or a shift toward weaker environmental protection and conservation policies. The

latter may lead to a lax enforcement of pollution regulations, further deforestation, and agricultural expansion at the expense of water and soil quality. In contrast, Monteiro, Russo, Gama, Lopes, and Borrego (2018) suggest that recessions may lead to long-term changes in consumer behavior with a potentially positive impact on the environment (i.e., shift to lower energy consumption). Overall, the literature finds mixed evidence on the long-term effect of economic shocks on environmental quality. Our analysis adds to the existing studies by going beyond a shock event and examining multiple aspects of environmental quality (i.e., biodiversity, forest, emissions, water, and agriculture) and potentially critical factors for sustainable transitions.

### 3 | METHODOLOGY

#### 3.1 | Approach

This study uses the period of “great stagnation” as a test case to examine the potential impact of a slowing down in economic growth on the environment. We use aggregate data at country level on environmental indicators for the level of biodiversity, agricultural and forestry activity, water resources, and atmospheric emissions. We use a model that comprises a dynamic panel data model using a GMM specification. Our variable of interest comprises a dummy as a proxy for the period of slow growth, the great stagnation. This variable is coded as zero from the beginning of our dataset up to 2009 and one from

2010 until 2019. Therefore, 2010 is considered the first year of the stagnation period excluding the drastic shock of the 2008–2009 financial crisis (see Figure 2). This evident fall in global GDP in constant terms is translated in a significant global output loss, and it is followed by a constant period of slow growth.

The environmental indicator of interest of country  $i$  in time  $t$ , as dependent variable can be denoted as  $Y_{it}$  ( $i = 1, \dots, n$ ;  $t = 1, \dots, T$ ), thus the model can be written as:

$$Y_{it} = \beta_0 + \beta_1 Y_{it-1} + \beta_2 \text{Stagnation}_{it} + \beta_3 \text{controls}_{it} + \varepsilon_{it}$$

where controls is a vector of control variables,  $Y_{it-1}$  is the lagged dependent variable to attenuate for potential omitted variable bias which might arise, as well as capturing the dynamic and temporal dependence of the independent variable. Finally,  $\varepsilon$  is the error term. We control for several indicators based on existing studies (Antoniades, Widiarto, & Antonarakis, 2019; Pacca et al., 2020). Appendix B, Table B1 provides a list with the controlling variables adopted for each regression.

We use the Arellano–Bond specification (Arellano & Bond, 1991) which includes second and deeper lags as instruments for the first lag of the dependent variable. The GMM models allow the correction of the potential bias resulting from the endogenous relationship between economic crisis and our environmental variables. Specifically, we adopt the two-step system GMM, or Arellano–Bover/Blundell–Bond estimator, which augments Arellano–Bond by adding the level equation in addition to the difference one and drastically improves its efficiency (Roodman, 2009). Furthermore, we compare our main specification (two lags) to a higher number of lags to make sure that results are robust across lag choices.

For the purpose of the analysis, the sample is divided into five groupings to enable a better understanding of the potential drivers in the relationship between great stagnation and environmental sustainability (Table 1). First, the countries were grouped into four income groups based on the World Bank Atlas Method (The World Bank, 2020a). Second, we present the results by geographically grouping countries into their respective continents. Third, we divided countries into three subgroups based on the percentage of forest area over the country's surface area. The first group (Low) comprises countries with an average forest area up to 17%. The second group (Mid) comprises countries with an average forest up to 50%, while the third group (High) up to 94%. Fourth, we divided the sample into three subgroups based on a country's dominant biomes (i.e., largest sq. km). This comprises three biomes subgroups including Montane, Temperate and Tropical (see Appendix C in Table C1). Fifth, we divide countries into four subgroups based on their average score in the Environmental Performance Index over 16 years (2000–2016). The first two groupings account for heterogeneity across income levels and geographical locations. The remaining three groupings account for country-specific environmental characteristics as an intervening variable on the impact of great stagnation. In particular, we are interested to examine whether “forest cover,” biomes and environmental performance make a difference in the degree of socio-environmental resilience in the context of a slowing down economy.

## 3.2 | Data

This study uses the latest data from a number of sources. Data on biodiversity comes from the Environmental Performance Index (EPI)-Yale (EPI-Yale, 2020). Data on agricultural land comes from the Climate Change Initiative (CCI LC) by the European Space Agency (2020) and from the World Development Indicators (WDI). Data on forest comes from the Global Forest Watch (GFW) and the Climate Change Initiative (CCI LC). Data on water comes from the Environmental Performance Index (EPI)-Yale (EPI-Yale, 2020) and the United Nations (2020). Finally, data on emissions come from the Potsdam Institute for Climate Impact Research (2020). Our unbalanced panel dataset comprises yearly observations of up to 217 countries (Table 1) worldwide between 1960 and 2018. Data for some indicators are available only from the 1980, whilst other from 1990 or 2000.

Table 2 presents the list of environmental indicators used with their sources (for definitions and modes of calculation of the different indicators see Appendix E).

## 4 | REGRESSION RESULTS

Tables 3 and 4 show the great stagnation's effect on the 15 environmental performance indicators. Specifically, Table 3 shows the regression results for the income- and continent groups, whereas Table 4 shows the results for the forest, biome, and environmental performance groups. The regressions comprise control variables as well as the lagged dependent variable.

### 4.1 | Biodiversity

At global level, the great stagnation is negatively associated with five out of six biodiversity variables examined. Terrestrial Protected Areas decreased by 1.6% (national weights) and 3.7% (global weights), Marine Protected Areas decreased by 22.8%, Fish Stocks decreased by 8.1%, and the Species Protection Index fell by 2.6%. The only biodiversity indicator that is improved is the species habitat index, increasing by 0.055%. The level of income exhibits the highest degree of correlation with biodiversity, in comparison to the other four groupings.

The stagnation period is associated with a negative effect on terrestrial protected areas statistically significant for lower mid- (−3.6%), upper mid- (−1.7%), and high-income (−2.4%) countries. This effect seems to be driven by countries in the Americas (−2.4%) (combined North and South), where the dominant biome is temperate (−2.2%) and belong to the low- (−1.5%) and mid- (−2.2%) forest areas groups. Similarly, the economic stagnation estimator is associated to a negative effect on species protection index for lower mid- (−2.8%), upper mid- (−2.4%) and high-income (−1.3%) countries. These results are driven by countries in Africa (−1.3%) and Europe (−1.5%), across all biome groups, with mid- (−1.1%) and high- (−1.7%) forest areas, and



TABLE 2 Environmental indicators

Group	Environmental indicator	Period	Source
Biodiversity	Terrestrial protected areas (global biome weights) (%)	(1990–2017)	(EPI)
	Terrestrial protected areas (National Weights) (%)	(1990–2017)	(EPI)
	Species protection index (% of habitat)	(1990–2014)	(EPI)
	Species habitat index (% of habitat)	(2001–2014)	(EPI)
	Fish stock status (% of catch)	(1950–2014)	(EPI)
	Marine protected areas (unitless)	(2000–2017)	(EPI)
Agriculture	Agricultural land (ha)	(1992–2015)	(cci)
	Agricultural land (ha)	(1961–2018)	(WDI)
Forest	Forest loss (ha)	(2001–2018)	(GFW)
	Tree-covered areas (ha)	(1992–2015)	(cci)
Water	Unsafe drinking water (life years lost per 100,000 persons)	(2000–2017)	(EPI)
	Wastewater treatment (% of population)	(1970–2018)	(un)
Emissions	CO <sub>2</sub> emissions (MtCO <sub>2</sub> e-Total excluding LULUCF)	(1970–2017)	(PIK)
	NO <sub>2</sub> emission (MtCO <sub>2</sub> e-Total excluding LULUCF)	(1970–2017)	(PIK)
	CH <sub>4</sub> emission (MtCO <sub>2</sub> e-Total excluding LULUCF)	(1970–2017)	(PIK)
	PM <sub>2.5</sub> air pollution, mean annual exposure (micrograms × m <sup>3</sup> )	(1990–2017)	(WDI)

Note: All indicators have been transformed into logarithmic form (see Table D1 in Appendix D).

belonging to the lower-mid- (2.3%) group of environmental performance index (EPI). In contrast, our results point to a minor but robust positive effect on species habitat index that extends to all our groupings and subgroupings (although the regression for Oceania does not pass the Hansen test, thus we cannot guarantee a robust result).

The effect of the stagnation estimator on the fish stock status is negative at a global level (−8.1%), although not significant for separate income, biome, and EPI groups. The global results are driven by countries in Africa (−8.1%). Forest area producing contradicting results: negative for low forest area (−10.6%) countries and positive (14%) for high forest area countries.

Lastly, the economic stagnation is associated with a negative impact on marine protected areas for high-income (−33.1%) countries, mainly in temperate biomes (−30.4%) and in Europe (−37.2%). The effect is negative for upper mid- (6.7%) and high-EPI (33%) countries, whilst this is positive for low-EPI (10.9%) countries.

## 4.2 | Agriculture

The great stagnation is linked to an increase in agricultural land at a global level by 0.8%, according to the World Development Indicators (WDI) FAO data. This increase is driven by 1.06% increases in upper mid-income countries, whereas we find smaller decreases in low- (−0.3%) and lower mid- (−0.2%) income countries. No statistically important results are observed for groupings beyond income. Using data on agricultural land from the Climate Change Initiative (CCI\_LC), we found no statistically significant at a global level, but a statistically significant negative link between stagnation and agricultural land for upper mid-income (−1.1%) countries and a positive link for high-income (0.3%) countries. Furthermore, great stagnation is associated

with a small negative and significant effect on agricultural land in low forest area (−0.1%) (CCI), as well as low-EPI (−0.1%) countries (WDI).

## 4.3 | Forest

The great stagnation is associated with a reduction in forest loss for upper mid-income countries and in the Asian continent, with decreases of 6.7% and 13%, respectively. There is a significant impact of stagnation on forest loss at the global level although the regressions do not pass either of the two statistical assumptions (Hansen, AR2 tests) thus these results are not considered. Regarding tree-covered areas from the CCI, the effect of stagnation is small, negative, and significant for low- (−0.3%) and high-income (−0.2%) countries, and for Europe (0.1%). Tree covered areas are also negative and statistically significant for mid-forest area (−0.2%), and low- (−0.2%), upper mid- (−0.1%), and high-EPI (−0.2%) countries.

## 4.4 | Water

The great stagnation is associated with a reduction in unsafe drinking water for high-income countries (−1.2%) and for Europe (−1.6%); however, we observe an increase in unsafe water for Americas (−2%) and for mid-forest area countries (−2.3%). Note again here that there are instances where significance is reported (global, Asian, high-forest area, tropical biome, and lower-mid and upper-mid-EPI countries), but do not pass the Hansen and AR2 tests. Regarding the wastewater treatment indicator, the regression result shows a negative and significant effect of stagnation in Europe (−3.6%) only. No other significant effect was found on any of the other subgroups.

**TABLE 3** Regression results on the effect of global stagnation on distinct environmental indicators for the income and continents subgroups

Dependent variable	Income group									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Global b (se)	Low b (se)	Lower-mid b (se)	Upper-mid b (se)	High b (se)	Americas b (se)	Asia b (se)	Africa b (se)	Europe b (se)	Oceania b (se)
Terrestrial protected areas (%EEZ-National Weights)	<b>-0.03669*</b> (0.019)	0.000 (0.017)	<b>-0.036*</b> (0.018)	<b>-0.017*</b> (0.008)	<b>-0.024**</b> (0.008)	<b>-0.024**</b> (0.008)	0.010 (0.021)	0.002 (0.018)	-0.017 (0.021)	0.622 (2.299)
Terrestrial protected areas (%EEZ-Global Weights)	<b>-0.01611**</b> (0.006)	-0.001 (0.005)	<b>-0.0337**</b> (0.015)	<b>-0.0134**</b> (0.007)	<b>-0.0214**</b> (0.007)	-0.0043 (0.018)	0.0806 (0.069)	0.0028 (0.023)	-0.0119 (0.013)	0.362 (3.327)
Species protection index (% species)	<b>-0.02589**</b> (0.009)	0.009 (0.029)	<b>-0.028**</b> (0.012)	<b>-0.024**</b> (0.009)	<b>-0.013**</b> (0.006)	0.002 (0.023)	-0.024 (0.028)	<b>-0.013**</b> (0.005)	<b>-0.015**</b> (0.006)	2.509 (1.568)
Species habitat index (% habitat)	<b>0.00055***</b> (0.000)	0.000 (0.000)	<b>0.0005**</b> (0.000)	<b>0.0008***</b> (0.000)	<b>0.0004***</b> (0.000)	<b>0.0005**</b> (0.000)	<b>0.0005**</b> (0.000)	<b>0.0003*</b> (0.000)	<b>0.0004**</b> (0.000)	-0.0005*** (0.000)
Fish stock status (% of catch)	<b>-0.08093**</b> (0.041)	-0.090 (0.441)	-0.008 (0.073)	0.014 (0.048)	-0.055 (0.055)	-0.0061 (0.038)	-0.0264 (0.044)	<b>-0.0806**</b> (0.036)	-0.0166 (0.100)	0.2036 (1.901)
Marine protected areas (unitless)	<b>-0.22823***</b> (0.057)	0.025 (0.031)	0.071 (0.085)	0.045 (0.056)	<b>-0.3307**</b> (0.159)	-0.0138 (0.104)	0.0626 (0.461)	0.0494 (0.039)	<b>-0.3718*</b> (0.218)	-0.3166 (0.250)
Agricultural land (ha) (CCI_LC)	0.002 (0.002)	0.000 (0.001)	0.006 (0.005)	<b>-0.011*</b> (0.006)	<b>0.003**</b> (0.001)	-0.001 (0.002)	-0.001 (0.001)	0.001 (0.002)	0.001 (0.001)	0.014 (0.019)
Agricultural land (ha) (WDI)	<b>0.00793*</b> (0.005)	<b>-0.0033**</b> (0.002)	<b>-0.0018*</b> (0.001)	<b>0.0106*</b> (0.005)	0.001 (0.003)	-0.0036 (0.005)	0.0217 (0.019)	-0.0008 (0.004)	0.0064 (0.008)	0.0011 (0.006)
Forest loss (ha/yr)	-0.04612*** (0.012)	0.155 (0.145)	-0.056 (0.086)	<b>-0.067**</b> (0.022)	0.010 (0.040)	-0.016 (0.027)	<b>-0.130**</b> (0.049)	0.006 (0.027)	0.113 (0.113)	0 (.)
Tree-covered areas (ha)	-0.00129** (0.001)	<b>-0.003*</b> (0.001)	-0.002* (0.001)	-0.009 (0.007)	<b>-0.002**</b> (0.001)	-0.001 (0.001)	0.001 (0.001)	-0.001 (0.002)	<b>-0.001**</b> (0.001)	-0.001 (0.002)
Unsafe drinking water (% of population)	0.02496** (0.008)	0.013 (0.028)	-0.031 (0.020)	0.002 (0.006)	<b>-0.0116*</b> (0.006)	<b>0.0198**</b> (0.007)	0.0337*** (0.009)	-0.0002 (0.005)	<b>-0.0157**</b> (0.006)	-0.0029 (0.013)
Wastewater treatment (% of population)	-0.012 (0.039)	0.000 (.)	0.005 (0.065)	-0.050 (0.051)	0.011 (0.063)	0.091 (0.148)	0.018 (0.027)	-0.093 (0.172)	<b>-0.036**</b> (0.017)	0 (.)
CO <sub>2</sub> emissions (MtCO <sub>2</sub> e- Total excluding LULUCF)	0.007 (0.007)	<b>0.0696*</b> (0.040)	-0.008 (0.017)	-0.032 (0.028)	<b>-0.0251***</b> (0.007)	-0.0004 (0.005)	0.004 (0.009)	0.0116 (0.030)	<b>-0.0182**</b> (0.007)	-0.0599 (0.045)
N <sub>2</sub> O emissions (MtCO <sub>2</sub> e- Total excluding LULUCF)	0.0075 (0.006)	<b>0.0220**</b> (0.011)	-0.0048 (0.007)	-0.0172 (0.025)	0.0076 (0.013)	0.017 (0.015)	-0.0152 (0.013)	0.0256 (0.017)	-0.0025 (0.010)	-0.1185 (0.214)
CH <sub>4</sub> emissions (MtCO <sub>2</sub> e- Total excluding LULUCF)	-0.003 (0.005)	-0.020 (0.025)	-0.021 (0.020)	<b>-0.0236*</b> (0.013)	0.003 (0.006)	-0.0011 (0.004)	<b>0.0121**</b> (0.006)	0.0032 (0.016)	<b>-0.0110**</b> (0.005)	0.0097 (0.013)
PM <sub>2.5</sub> pollution (micrograms per cubic meter)	-0.0315***	-0.042	<b>-0.0185**</b>	<b>-0.0458***</b>	-0.0518**	-0.0244***	-0.0138***	-0.0089	-0.0191***	-0.0199***

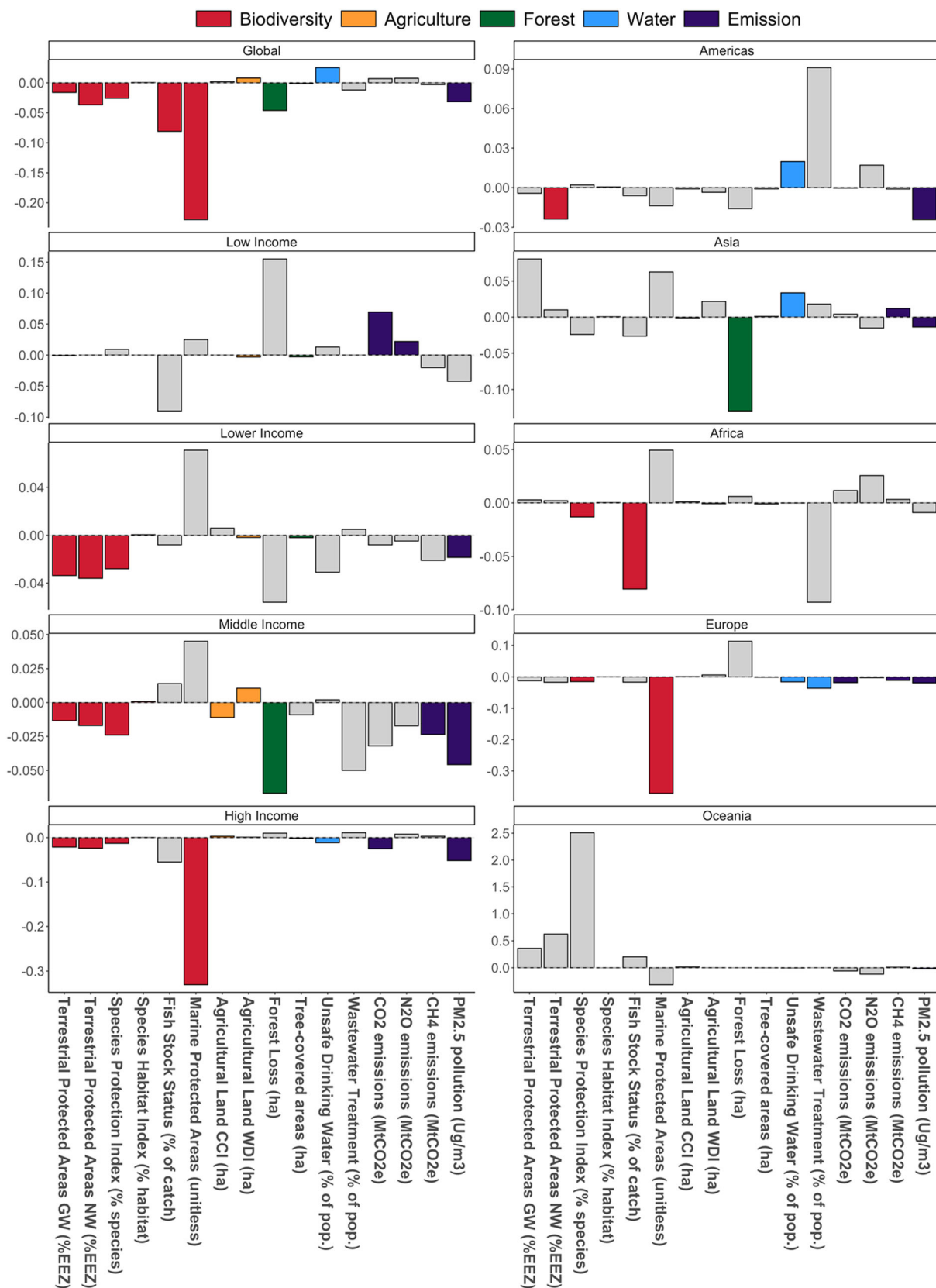
Note: All dependent variables are in logarithmic form. The table reports estimates and robust standard errors underneath. All results come from system two-step GMM specifications. Only the lagged dependent variable is treated as endogenous and instrumented with its second lag or higher, while all the other variables are treated as exogenous. Standard errors are shown in brackets. Values in bold have passed both Hansen and Arellano 2 tests. \* $p < 10\%$  is the significance level. \*\* $p < 5\%$  is the significance level. \*\*\* $p < 1\%$  is the significance level.



**TABLE 4** Regression results on the effect of global stagnation on distinct environmental indicators for the forest, biome, and environmental performance index subgroups

Depended variable	Forest area			Biomes		Environmental performance				
	(1) Low b (se)	(2) Mid b (se)	(3) High b (se)	(4) Polar b (se)	(5) Temperate b (se)	(6) Tropical b (se)	(7) Low b (se)	(8) Lower-mid b (se)	(9) Upper-mid b (se)	(10) High b (se)
Terrestrial protected areas (National Weights)	<b>-0.015**</b> (0.006)	<b>-0.022***</b> (0.004)	0.023 (0.020)	-0.011 (0.013)	<b>-0.022***</b> (0.006)	0.012 (0.013)	0.028 (0.031)	0.041 (0.074)	0.002 (0.007)	0.026 (0.025)
Terrestrial protected areas (Global Weights)	0.0001 (0.012)	<b>-0.0216***</b> (0.004)	0.0395 (0.030)	-0.0006 (0.016)	<b>-0.0188*</b> (0.010)	0.0252 (0.020)	0.0219 (0.039)	-0.0002 (0.020)	-0.0042 (0.010)	-0.0002 (0.011)
Species protection index (% species)	-0.006 (0.022)	<b>-0.011**</b> (0.005)	<b>-0.017**</b> (0.007)	<b>-0.026**</b> (0.012)	<b>-0.022*</b> (0.012)	<b>-0.015*</b> (0.009)	-0.013 (0.029)	<b>-0.023***</b> (0.007)	-0.01 (0.006)	0.018 (0.027)
Species habitat index (% habitat)	<b>0.0002**</b> (0.000)	<b>0.0005***</b> (0.000)	<b>0.0008***</b> (0.000)	0.0002 (0.000)	<b>0.0004***</b> (0.000)	<b>0.0005***</b> (0.000)	<b>0.0003**</b> (0.000)	<b>0.0007***</b> (0.000)	<b>0.0006***</b> (0.000)	<b>0.0008***</b> (0.000)
Fish stock status (% of catch)	<b>-0.1068**</b> (0.053)	0.0018 (0.022)	<b>0.1401**</b> (0.067)	-0.4596 (0.298)	-0.0274 (0.035)	0.0343 (0.038)	0.1405 (0.195)	-0.0532 (0.053)	0.0157 (0.062)	0.0204 (0.077)
Marine protected areas (unitless)	0.0839 (0.060)	-0.1673 (0.124)	-0.2763 (0.197)	-0.05 (0.033)	<b>-0.3038**</b> (0.124)	0.0179 (0.026)	<b>0.1089**</b> (0.049)	-0.0577 (0.116)	<b>-0.0673</b> (0.046)	<b>-0.3303**</b> (0.167)
Agricultural land (ha) (CCI_LC)	<b>-0.001**</b> (0.000)	0.001 (0.001)	0.004 (0.005)	0.000 (0.001)	0.000 (0.000)	0.006 (0.004)	0.0008 (0.002)	0.0024 (0.005)	0.0005 (0.004)	0.0001 (0.007)
Agricultural land (ha) (WDI)	0.0023 (0.003)	0.0003 (0.007)	-0.002 (0.005)	0.0007 (0.001)	0.0016 (0.005)	-0.0006 (0.006)	<b>-0.001*</b> (0.001)	0.007 (0.006)	-0.005 (0.004)	0.000 (0.001)
Forest loss (ha/yr)	-0.127** (0.057)	-0.028 (0.027)	-0.034 (0.074)	-0.084 (0.071)	-0.03 (0.027)	-0.027 (0.017)	-0.001 (0.035)	-0.041 (0.038)	-0.054** (0.023)	0.022 (0.055)
Tree-covered areas (ha)	-0.002 (0.001)	<b>-0.002*</b> (0.001)	0.000 (0.000)	-0.001 (0.011)	-0.001 (0.001)	0.000 (0.004)	<b>-0.002**</b> (0.001)	0.000 (0.001)	<b>-0.001**</b> (0.001)	<b>-0.002*</b> (0.001)
Unsafe drinking water (% of population)	0.0107 (0.008)	<b>0.0229*</b> (0.014)	0.0119** (0.005)	-0.0093 (0.011)	0.0153 (0.010)	0.0149* (0.008)	-0.0058 (0.008)	0.0118** (0.006)	0.0169** (0.008)	-0.0093 (0.013)
Wastewater treatment (% of population)	-0.105 (0.094)	-0.036 (0.032)	0.041 (0.134)	-0.151 (0.184)	-0.017 (0.018)	-0.014 (0.139)	-0.054 (0.149)	0.012 (0.024)	0.019 (0.036)	-0.087 (0.158)
CO <sub>2</sub> emissions (MtCO <sub>2</sub> e- Total excluding LULUCF)	-0.0033 (0.008)	0.0095 (0.013)	<b>0.0203*</b> (0.012)	0.0114 (0.019)	<b>-0.0135*</b> (0.007)	<b>0.0306**</b> (0.013)	-0.0019 (0.022)	0.007 (0.011)	-0.0081 (0.022)	-0.0081 (0.022)
N <sub>2</sub> O emissions (MtCO <sub>2</sub> e- Total excluding LULUCF)	-0.0098 (0.010)	<b>0.0181*</b> (0.010)	0.0019 (0.005)	0.0208 (0.036)	-0.0107 (0.007)	-0.0037 (0.007)	-0.0072 (0.007)	0.0026 (0.006)	<b>-0.0161*</b> (0.009)	<b>0.0220*</b> (0.012)
CH <sub>4</sub> emissions (MtCO <sub>2</sub> e- Total excluding LULUCF)	0.0006 (0.014)	-0.0039 (0.003)	0.0038 (0.005)	-0.0009 (0.005)	0.0005 (0.004)	-0.0032 (0.003)	0.005 (0.006)	0.000 (0.007)	-0.0066 (0.011)	<b>0.0166**</b> (0.008)
PM <sub>2.5</sub> pollution (micrograms per cubic meter)	<b>-0.0119***</b> (0.003)	-0.0182*** (0.002)	<b>-0.0206***</b> (0.003)	-0.0229*** (0.003)	<b>-0.0162***</b> (0.002)	-0.0143*** (0.003)	<b>-0.0133**</b> (0.005)	<b>-0.0104***</b> (0.003)	-0.0219*** (0.003)	<b>-0.0227***</b> (0.002)

Note: All dependent variables are in logarithmic form. The table reports estimates and robust standard errors underneath. All results come from system two-step GMM specifications. Only the lagged dependent variable is treated as endogenous and instrumented with its second lag or higher, while all the other variables are treated as exogenous. Standard errors are shown in brackets. Values in bold have passed both Hansen and Arellano 2 tests. \* $p < 10\%$  is the significance level. \*\* $p < 5\%$  is the significance level. \*\*\* $p < 1\%$  is the significance level.



**FIGURE 3** The effect of the great stagnation on environmental indicators by income groups (LHS) and continents (RHS) based on the regression results reported in Table 3. Only significant values are shown in white whilst non-significant values are shown in grey colour. Units in the y-axis are different for each indicator and shown in brackets beside each indicator [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

## 4.5 | Emissions

Looking at atmospheric emissions, the great stagnation is linked to an increase in CO<sub>2</sub> emissions in low-income countries (6.9%), high-forest area (2%), and a dominant tropical biome (3%), but a decrease in high-income countries (−2.5%), in Europe (−1.8%) and in countries with a dominant temperate biome (−1.3%). On N<sub>2</sub>O emissions, we observe an increase in low-income countries (2.2%), mid-forest area (1.8%), and high-EPI countries (2.2%). On CH<sub>4</sub>, we observe a reduction in emissions for upper mid-income countries (−2.3%), and Europe (−1.1%), with increases in Asia (1.2%) and at high-EPI countries. Finally, the great stagnation is associated with decreases in PM<sub>2.5</sub> by 1.85% in lower mid-income countries and 4.6% in upper mid-income countries. There are effects at the continent level, but the regressions do not meet the fundamental assumptions (i.e., the Hansen and AR2 tests). The same applies for the results in polar and tropical biomes and upper mid-EPI countries. Otherwise, statistically important reductions are observed in the other sub-groupings, that is, forest areas, biomes, and EPI.

## 4.6 | Robustness of the results

A series of robustness checks have been carried out to assess the consistency of the estimates across different specifications (see Table F1, Appendix F). We used an alternative GMM specification, with the lagged dependent variable and stagnation treated as endogenous, as some unobserved factors with a potential effect on the stagnation period could contribute to determining the slow growth period as well as simultaneously change environmental policies (Pacca et al., 2020). All other controlling variables have been treated as strictly exogenous. The results from the modified GMM from Table F1 are similar to the results from Table 3. In general, the sign and the significance of the stagnation estimator on our environmental variables are in line in the two different GMM specifications. Furthermore, a generalized least square (GLS) with countries and years fixed effects is reported in Table F1. The results from the GMM are consistent with the fixed effect in terms of significance and sign, whilst the GLS models show a higher magnitude of the stagnation estimators as they do not take into account the endogeneity of the lagged dependent variable. Finally, as a further robustness check, we reduced the number of years by setting the starting point to the year 2000 for every environmental indicator. The results (available upon request) remained unchanged.

We provide a visual representation of our results in Figure 3.

## 5 | DISCUSSION

### 5.1 | Macro-level findings

The period of great stagnation offers a fertile ground to test the implications of a sustained slowdown in economic activity on the environment. We expect that a reduction in economic growth rates would in principle have a positive impact on the environment (Krausmann

et al., 2009; UNEP, 2011). Yet, we also expect that a reduction in growth rates will have an adverse impact on important socio-economic indicators, such as on livelihoods, employment and investments, which may negatively affect the impact of the economic slowdown on the environment. Understanding the complex relationship among these dynamics is critical to manage the needed transition to a socio-environmentally sustainable model.

Based on our results, three observations are important at a macro-level. First, the great stagnation, as a period of persistent slower growth, does not produce a homogenous positive impact on the environment. On the contrary, we observe diversity in environmental trends across different country groupings, as well as a deterioration in some environment indicators, especially related to biodiversity. Consequently, “degrowth” conceived purely in quantitative terms as a reduction in the rate of growth, regardless of the drivers of this reduction, does not seem to lead to environmental sustainability. Second, we found that secular stagnation has an impact at global level on 6 out of 15 environmental indicators. Yet, results at global- and sometimes income- level seem to obscure important heterogeneity of trends and dynamics at geographical level. For instance, the observed reduction in terrestrial protected areas is concentrated in the Americas, whereas the negative results on species protection are driven by Africa and Europe. Similarly, the results on the reduction in fish stock status are driven by Africa, whereas the negative impact on marine protected areas is focused in Europe. Thus, similar global pressures are materialized differently on the ground, and observed global impacts are driven by specific geographical locations and dynamics. Third, the forest area, biome, and environmental performance index do not seem to significantly influence the relationship between the great stagnation and the environment. In this regard we observe that countries with high forest cover in tropical countries may shield effects of biodiversity loss better than temperate countries and those with medium forest area. The results on dominant biomes also point to interesting differences between temperate and tropical biomes in CO<sub>2</sub> emissions. The Environmental Performance Index shows an even weaker picture. Here, at places, the results are counter-intuitive (e.g., in marine protected areas, N<sub>2</sub>O and CH<sub>4</sub> emissions).

Overall, despite the historically exceptional and persistent slowdown of growth rates that we have seen over the last decade, this period is not associated with exclusively positive environmental dynamics. The relationship between great stagnation and the environment is mixed. Our results indicate a deterioration in biodiversity, and some increases in CO<sub>2</sub> and N<sub>2</sub>O emissions, along with improvements in PM<sub>2.5</sub> and CH<sub>4</sub> emissions, forest loss, and species habitat index. Thus, although economic growth has negative environmental consequences (OECD, 2008; Vadén et al., 2020; Ward et al., 2016; Wiedmann et al., 2015), the environmental consequences of slower economic growth appear to be mixed, diverse across different regions, and sensitive to policy responses (Bowen & Stern, 2010). Therefore, degrowth as a strategy to transitioning to sustainability cannot be thought of as a quantitative target or threshold. Rather it should be thought in qualitative terms as a strategy, a set of policies that aim to rebase our economic model on a more sustainable footing.

## 5.2 | Effects on the five environmental categories

### 5.2.1 | Biodiversity

Beyond the macro-level, it is important to examine the impact of the great stagnation on our five environmental categories. Most biodiversity indicators deteriorated. The results suggest that the prolonged period of global economic stagnation is associated with a contraction in Terrestrial and Marine Protected Areas, Species Protection Index, and Fish Stocks. The only biodiversity indicator that was improved is the Species Habitat index. The reduction in terrestrial protected areas (TPA) at global level (−3.7% in national weights; −1.6% in global weights) may be attributed to what the latest UNEP-WCMC (2018:7) report refers to as “tapering off” effect during this period (available data up to 2017) (see also Lewis et al., 2019). Yet, our TPA results in national weights demonstrate that the negative impact is driven by developments in the American continent (reduction of 2.4%). This is a more worrying finding as it may point to a geographically concentrated scaling back of protected areas, a process called Protected Area Downgrading, Downsizing and Degazettement (or PADDD) (ibid:7), with primary causes being industrial level activities, energy projects and local land pressures (Mascia et al., 2014). These results come to support recent findings that demonstrate for instance that PADDD has impacted Brazil's protected area network (Pack et al., 2016). North America is also affected. According to Lewis et al. (2019:577), the USA has the highest negative footprint in this area between 2006 and 2016, although the reason for this is not mostly PADDD but changes in the IUCN definition of a protected area. Another potential driver here, especially in central and southern America, Africa, and Asia is the increase in cattle farming and oil seed production, which has been a major factor in biodiversity loss (Marques et al., 2019). In the case of high-income countries, biodiversity loss may have also been driven by a shift toward austerity policies that are associated with a worsening of environmental standards and protection (Botetzagias, Tsagkari, & Malesios, 2018; Lekakis & Kousis, 2013).

With regard to marine protected areas (MPA), the latest UNEP-WCMC (2018, p.7) reports increases during the great stagnation period (rising from 2% in 2010 to 6% in 2017 of the world's oceans), whereas our results point to a reduction (−0.23%). Yet the latter is mostly coming from high-income countries (−0.34%), the European continent (−0.37%), and areas where the dominant biome is temperate (−0.30%). For all other income groups and continents, no statistically significant impact is observed which indicates that there may not have been a significant difference in trend during the great stagnation period. Despite significant weaknesses in the European MPA (see WWF, 2019), further research is required to establish whether the negative impact observed in the European continent is due to a stricter application of IUCN definition or other developments on the ground. With regard to fish stocks, the negative impact at global level is significant (−8.1%), but again the result is only statistically significant in the African continent (−8.06%). This is in line with recent reports and evidence on the significant deterioration of fish stocks in Africa

(e.g., BBC, 2018; Hilborn et al., 2020; McClanahan, 2019; McClanahan et al., 2019). Furthermore, marine protected areas do not necessarily reduce fishing pressures (Agardy, di Sciara, & Christie, 2011; Bates et al., 2019), especially if only a small percentage of oceans is protected (Dasgupta, 2018). Yet, the difference that the great stagnation makes to fisheries is notable, although data are available only until 2014, and therefore the duration of great stagnation here is only 5 years.

The Great Stagnation had differing impact on the Species Protection Index (SPI) and the Species Habitat Index (SHI), but it is notable that in both cases this impact was rather diffused (across most income groups and several continents). The reduction in SPI at global level (−2.6%) is driven by reductions in the African (−1.3%) and European (−1.5%) continents. On the other hand, there is moderate positive impact on SHI at a global level (0.055%) that spreads across most income groups (except low-income) and continents (except Oceania). These results suggest that although both terrestrial protected areas and species protection are decreasing, the existing habitat ecosystem could be improving, or it is likely that the decrease in the trend of habitat destruction could be levelling off for a number of species and ecosystems. This levelling off since 2010 has been seen in the similar Living Planet Index (Grooten & Almond, 2018). Another reason could be due to the natural growth of vegetation seen from remote sensing (involved in calculating the SHI) as well as effective conservation of the protected areas (note data for SPI and SHI are available only until 2014).

### 5.2.2 | Agriculture

To examine changes in agricultural land during the great stagnation, we use two different datasets produced respectively by CCI (data up to 2015) and FAO (data up to 2018) (for a comparison see Pérez-Hoyos, Rembold, Kerdiels, and Gallego, 2017). Results for both datasets are not statistically significant at continental level. Yet for both datasets, the impact of great stagnation on agricultural land is contingent on income level—lower-income countries see a reduction in agricultural land, whereas high-income countries see an expansion in agricultural land. Yet, the different results are not compatible as they identify different income groups. Taking into consideration Pérez-Hoyos et al. (2017) comparison of these datasets, as well as the different duration of the two datasets, we focus on results based on FAO (WDI) data. The global stagnation is associated with an expansion in agricultural land at global level (0.79%). This expansion is driven by an expansion in upper mid-income countries (1.06%), but at the same time, we see reduction in low- and lower mid-income countries (−0.33% and −0.13% respectively). The explanation for these contrasting tendencies may be that in poor countries the great stagnation leads to population moves to urban areas (in search for income and possible to escape adverse climate events), whereas in upper mid-income developing countries the same conditions lead to an expansion of agricultural land for industrial production and exports. In line with the above findings on biodiversity, these findings indicate that slower growth, instead of producing a monotonic positive impact on

the environment it produces diverse results on the basis of different local socio-economic conditions and policy responses.

### 5.2.3 | Forests

The relationship between great stagnation and forest cover is also mixed depending on the dataset used. During the stagnation period, forest loss (obtained from the Global Forest Watch) did not change at the global level but was significantly lowered in upper mid-income countries (−6.7%), and in Asia (−13%). Globally, deforestation was coming up against international efforts to decrease, halt, or restore forests since 2010. NGOs and industry were committed to new conservation initiatives such as Reducing Emissions from Deforestation and Degradation (REDD), the Bonn Challenge, the New York Declaration on Forests, zero deforestation policies by companies and more. Yet the last decade, and especially since 2016 from the GFW, has seen deforestation remain high or increase in many regions of the world, coupled with higher instances of forest fires in tropical, Mediterranean, and boreal countries. The economic slowdown may have cancelled or delayed the effects of these international and national forest initiatives as countries have scrambled to use forest resources to support their economy—namely for palm oil, soybean, timber wood, cattle, but also for the expansion of shifting agriculture (Curtis, Slay, Harris, Tyukavina, & Hansen, 2018). Asia dominates the conversion of forest into oil palm in the last decade (Gro-Intelligence, 2016; USDA PS&D, 2020), but also has witnessed high reforestation especially in temperate Asia, namely China (FAO, 2016). Therefore, the GFW results on decreasing deforestation in Asia may be confounded by a larger instance of timber and palm oil plantations. Conversely to the GFW, the CCI results show that the great stagnation period showed decreases in forest cover in low- and high-income countries, and in Europe. These results are not consistent. This may be because: (a) the GFW does not consider forest growth due to reforestation, plantation expansions, or natural regeneration of forests; (b) the CCI uses coarser resolution satellite imagery (AVHRR, MERIS, SPOT, and PROBA-V) meaning many pixels will be a mosaic of forest and non-forest types. Also, it would be expected that a decrease in forest cover would be met with an increase in agricultural land from the CCI, but this is only matched in high-income countries (see Table 3).

### 5.2.4 | Water

Dynamics regarding unsafe drinking water (UDW) during the great stagnation differ across income and continent levels. High-income countries, driven by the European continent, experience a decrease in UDW (−1.16% and −1.57% respectively). Yet in the Americas, we observe an increase in UDW by 1.98% (we also observe an increase of 3.37% in Asia, but the regression does not pass the AR2 test, thus we cannot guarantee a robust result). The increase in the Americas may be driven by developments both in central and south America, due to economic hardship, but also in the United States, which experienced significant challenges in this area recently (Suh, 2019).

### 5.2.5 | Emissions

Finally, the results on GHG emissions are mixed, pointing that a period of degrowth is not necessarily associated with a reduction in greenhouse gas emissions, even if we have seen initiatives and agreements related to these emissions in the last 10–15 years including the 2009 Copenhagen summit, the 2015 Paris Agreement, the 2008 EU Ambient Air Quality Directive, and the WHO Global Platform on Air Quality and health since 2014. In terms of air quality, we observe a reduction in PM<sub>2.5</sub> emissions by 1.85% in lower-mid-income countries and 4.6% in upper-mid-income countries. For CO<sub>2</sub> emissions, we find no impact at global level, a decrease in high-income countries (−2.5%), driven by Europe (−1.8%) and temperate biome areas (−1.35%), but a significant increase in low-income countries (6.9%). CO<sub>2</sub> has been increasing also in countries with tropical biomes, and with high-forest area. A potential explanation of our emission results is the decrease in green government spending in East Asia after the Great Financial Crisis (i.e., spending for renewable energy use, waste reduction and recycling, emission control programmes, and green energy efficient technologies) (Elliott, 2011; Pacca et al., 2020). Furthermore, the rise in CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O emissions could be linked to Chinese investments in low-income countries in southeast Asia (Brown, 2016; Frost, 2004; Frost & Ho, 2005; Pheakdey, 2013; Yeh, 2016) as well as in central America (Sanborn & Chonn, 2015) and central Africa (Shen, 2013). We also observe increases in N<sub>2</sub>O emissions in low-income countries (2.2%). The main driver for the CO<sub>2</sub> and N<sub>2</sub>O increases in low-income countries should be the historically high growth rates experienced in these countries during this period (Steinbach, 2019), along with population growth (van Beek, Meerburg, Schils, Verhagen, & Kuikman, 2010). CH<sub>4</sub> emissions have been decreasing in upper mid-income countries (−2.3%) and in Europe (−1.10%). Yet we estimate increases in Asia (1.21%). Several countries have initiated plans to decrease emissions during the last decade. However, a possible reason for lower GHG in Europe is due to the offshoring production in other countries, in particular those from Asia (Hurley, Storrie, & Peruffo, 2016). Lastly, in contrast to prior research (Santamouris et al., 2013; Saffari et al., 2013), our PM<sub>2.5</sub> findings do not point to a clear shift in energy consumption habits by people in developing countries, such as the use of alternative energy sources (i.e., wood burning).

### 5.3 | Limitations of the study

A number of limitations may be noted. First, limited data availability constrains the number of indicators that can be used in the different environmental domains and as control variables for the great stagnation period. Second, we do not have similar time periods for every indicator (see robustness tests). The main issue here, however, is that some of the biodiversity and forest indicators are available only for a reduced number of years (i.e., up to 2014/5 in some instances), resulting in a shorter stagnation period, and reduced comparability between indicators. Third, although some of our indicators do not directly measure environmental impact (i.e., wastewater treatment, unsafe drinking water), these social indicators may be considered as



proxies for trends in the respective environmental domains. Lastly, although our indicators are able to capture a good part of the human impact on the planet, other critical environmental externalities have not been considered (e.g., general/hazardous waste). Likewise, we do not consider the role played by governments' environmental efforts. To this extent, we suggest future research to consider for example the role played by environmental related (green) technologies as well as the circular economy. Constraints in global data availability did not allow us to integrate such factors in our analysis. We further recommend using a narrower approach for later research that would potentially focus on a few specific environmental quality indicators, to improve the empirical analysis with more control variables and robust indicators (e.g., using longer time periods and/or different indicators).

## 6 | CONCLUSIONS

Periods of economic slowdown have been linked to an amelioration of environmental quality due to a slowdown in energy use, resource extraction (water, timber, and minerals), and greenhouse gas emissions. This further emphasizes the direct link of the economy to the environment (Bowen & Stern, 2010; Dietz & Adger, 2003; Mills & Waite, 2009; Stern, 2006), which has been demonstrated once again during the Coronavirus pandemic (Antonarakis, 2020). Recent evidence has shown that improvement in environmental quality during economic crises is short-lived, and the environment deteriorates again 1 or 2 years after the break-out of the crisis (Elliott, 2011; Pacca et al., 2020).

The decade after the Great Financial Crisis is one of the longest periods of persistent global economic slowdown after WWII. We used this setting to examine the impact of a systemic economic slowdown on environmental sustainability at the global level. We developed a novel research approach in which we examine the relationship between the great stagnation and 15 environmental indicators comprising of five distinct environmental categories (i.e., biodiversity, water, forest, agriculture, and emissions) across five groupings (i.e., income groups, continents, forest cover, biome, and environmental performance index). In this way, we account for a large number of potential drivers of environmental change in periods of slow growth.

We find that the period of great stagnation is associated with mixed environmental dynamics, both in terms of direction and location. For instance, we observe that the great stagnation is associated with a deterioration in biodiversity in terrestrial as well as marine ecosystems at the global level, and with improvements in some air pollutant emissions ( $PM_{2.5}$ ,  $CO_2$ ,  $CH_4$ ) in middle- and high-income countries. These mixed effects are differently distributed across continents. For instance, the deterioration in "terrestrial protected areas" is driven by the Americas, in "marine protected areas" by Europe, of the "species protection index" by Europe and Africa, and of "global fish stocks" by Africa. Respectively, improvements in  $CO_2$  and  $CH_4$  emissions are concentrated in Europe, while, at the same time, we observe increases in  $CH_4$  emissions in Asia.

The level of income seems to be a key determinant for environmental outcomes during the period of great stagnation, followed by the continental grouping that most times come to add specificity in relation to income groups. Groupings related to forest area, biome, and environmental performance index do not have a major impact on explaining environmental effects of the stagnation period, save some evidence of worsening environment quality in medium forest cover and temperate countries.

The Sustainable Development Goals (SDGs) have strongly advocated for the synergy between economic growth, poverty alleviation, and environmental improvement. The importance of this synergy has been widely advocated during the Coronavirus pandemic too (Dasgupta & Andersen, 2020; Florizone, 2020; Nature Editorial, 2020). Yet, for GDP growth to be sustainable it would have to be decoupled from energy and material use and thus environmental impacts, and there is limited evidence that this is possible for all countries across many environmental domains (Vadén et al., 2020; Ward et al., 2016; Wiedmann et al., 2015). What our study does indicate is that in the last decade there was no clear or strong coupling of economic slowdown and environmental improvements, with global decreases in biodiversity indicators but no strong evidence on global emissions, water, and forest loss. Our study therefore shows that even a "new normal" based on slower economic growth does not necessarily lead to better overall environmental outcomes. Put differently, slower economic growth on its own cannot ensure transition to a sustainable socio-environmental system.

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## REFERENCES

- Agardy, T., di Sciara, G. N., & Christie, P. (2011). Mind the gap: Addressing the shortcomings of marine protected areas through large scale marine spatial planning. *Marine Policy*, 35(2), 226–232. <https://doi.org/10.1016/j.marpol.2010.10.006>
- Antonarakis, A. S. (2020). *Environment and poverty during the coronavirus crisis: A lesson for global collaboration.*, SSRP forum: The pandemic and sustainability. Retrieved from [https://www.sussex.ac.uk/ssrp/resources/forum/alexander-antonarakis?fbclid=IwAR0xTgEbFLxdAote5EGy\\_fcnMxaeSQGujEY3P0l5mokPj6Z9U1u47IJE\\_E](https://www.sussex.ac.uk/ssrp/resources/forum/alexander-antonarakis?fbclid=IwAR0xTgEbFLxdAote5EGy_fcnMxaeSQGujEY3P0l5mokPj6Z9U1u47IJE_E)



- Antoniades, A., & Griffith-Jones, S. (2018). Global debt dynamics: The elephant in the room. *The World Economy*, 41, 3256–3268.
- Antoniades, A., Widiarto, I., & Antonarakis, A. S. (2019). Financial crises and the attainment of the SDGs: An adjusted multidimensional poverty approach. *Sustainability Science*, 15, 1683–1698. <https://doi.org/10.1007/s11625-019-00771-z>
- Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The Review of Economic Studies*, 58(2), 277. <https://doi.org/10.2307/2297968>
- Barrett, A. B. (2018). Stability of zero-growth economics analysed with a Minskyan model. *Ecological Economics*, 146(May 2017), 228–239. <https://doi.org/10.1016/j.ecolecon.2017.10.014>
- Bates, A. E., Cooke, R. S. C., Duncan, M. I., Edgar, G. J., Bruno, J. F., Benedetti-Cecchi, L., ... Stuart-Smith, R. D. (2019). Climate resilience in marine protected areas and the “protection paradox”. *Biological Conservation*, 236 (May 2018), 305–314. <https://doi.org/10.1016/j.biocon.2019.05.005>
- BBC. (2018). “Fish are vanishing”-Senegal's devastated coastline. Retrieved from <https://www.bbc.com/news/world-africa-46017359>
- Botetzagias, I., Tsagkari, M., & Malesios, C. (2018). Is the “troika” bad for the environment? An analysis of EU countries' environmental performance in times of economic downturn and austerity memoranda. *Ecological Economics*, 150, 34–51. <https://doi.org/10.1016/j.ecolecon.2018.04.001>
- Bowen, A., & Stern, N. (2010). Environmental policy and the economic downturn. *Oxford Review of Economic Policy*, 26(2), 137–163. <https://doi.org/10.1093/oxrep/grq007>
- Brown, R. (2016). Where will the new silk road lead? The effects of Chinese investment and migration in Xinjiang and Central Asia. *The Journal of Politics and Society*, 26, 69–91.
- Cosme, I., Santos, R., & O'Neill, D. W. (2017). Assessing the degrowth discourse: A review and analysis of academic degrowth policy proposals. *Journal of Cleaner Production*, 149, 321–334. <https://doi.org/10.1016/j.jclepro.2017.02.016>
- Cotta, B. (2020). What goes around, comes around? Access and allocation problems in global north–south waste trade. *International Environmental Agreements: Politics, Law and Economics*, 20(2), 255–269. <https://doi.org/10.1007/s10784-020-09479-3>
- Curtis, P. G., Slay, C. M., Harris, N. L., Tyukavina, A., & Hansen, M. C. (2018). Classifying drivers of global forest loss. *Science*, 361(6407), 1108–1111. <http://dx.doi.org/10.1126/science.aau3445>
- D'Alisa, G., Demaria, F., & Kallis, G. (2015). In G. D'Alisa, F. Demaria, & G. Kallis (Eds.), *Degrowth: A vocabulary for a new era*. Oxon and New York, NY: Routledge.
- Dasgupta, P., & Andersen, I. (2020). Covid-19 is nature sending us a message—we must listen. *The Independent*. Retrieved from <https://www.independent.co.uk/news/business/analysis-and-features/biodiversity-economy-coronavirus-covid-19-dasgupta-review-a9550156.html>
- Dasgupta, S. (2018). *The ups and downs of marine protected areas: Examining the evidence, Mongabay Series: Conservation Effectiveness*. Retrieved from <https://news.mongabay.com/2018/01/the-ups-and-downs-of-marine-protected-areas-examining-the-evidence/>
- Davidson, E. A. (2009). The contribution of manure and fertilizer nitrogen to atmospheric nitrous oxide since 1860. *Nature Geoscience*, 2(9), 659–662.
- Dietz, S., & Adger, W. N. (2003). Economic growth, biodiversity loss and conservation effort. *Journal of Environmental Management*, 68(1), 23–35. [https://doi.org/10.1016/S0301-4797\(02\)00231-1](https://doi.org/10.1016/S0301-4797(02)00231-1)
- El-Erian, M. (2009, May). *A new normal, PIMCO Secular Outlook*.
- Elliott, L. (2011). Shades of green in East Asia: The impact of financial crises on the environment. *Contemporary Politics*, 17(2), 167–183. <https://doi.org/10.1080/13569775.2011.565985>
- EPI-Yale. (2020). *Environmental performance index*. Retrieved from <https://epi.yale.edu>
- FAO. (2016). *State of the world's forest. Forest and agriculture: Land-use challenges and opportunities*. Rome: FAO.
- Florizone, R. (2020). *Three ways the coronavirus is shaping sustainable development*. The International Institute for Sustainable Development (IISD). Retrieved from <https://www.iisd.org/articles/three-ways-coronavirus-shaping-sustainable-development>
- Frost, S. (2004). Chinese outward direct investment in Southeast Asia: How big are the flows and what does it mean for the region? *Pacific Review*, 17(3), 323–340. <https://doi.org/10.1080/0551274042000261489>
- Frost, S., & Ho, M. (2005). “Going out”: The growth of Chinese foreign direct investment in Southeast Asia and its implications for corporate social responsibility. *Corporate Social Responsibility and Environmental Management*, 12(3), 157–167. <https://doi.org/10.1002/csr.98>
- Global Forest Watch. (2020). *Forest loss*. Retrieved from <https://data.globalforestwatch.org>
- Gro-Intelligence. (2016). *Palm oil: Growth in Southeast Asia comes with a high price tag*. Retrieved from <https://gro-intelligence.com/insights/articles/palm-oil-production-and-demand>
- Grooten, M., & Almond, R. E. A. (2018). *Living planet report-2018: Aiming higher*. Living Planet Report-2018: Aiming Higher, WWF International.
- Haldane, A. G. (2015, February). Growing, fast and slow. pp. 1–27.
- Hardt, L., & O'Neill, D. W. (2017). Ecological macroeconomic models: Assessing current developments. *Ecological Economics*, 134, 198–211. <https://doi.org/10.1016/j.ecolecon.2016.12.027>
- Hilborn, R., Amoroso, R. O., Anderson, C. M., Baum, J. K., Branch, T. A., Costello, C., ... Ye, Y. (2020). Effective fisheries management instrumental in improving fish stock status. *Proceedings of the National Academy of Sciences of the United States of America*, 117(4), 2218–2224. <https://doi.org/10.1073/pnas.1909726116>
- Hurley, J., Storrie, D., & Peruffo, E. (2016). *ERM annual report 2016: Globalisation slowdown? Recent evidence of offshoring and reshoring in Europe*. Publications Office of the European Union.
- IMF. (2020). *Real GDP growth*. Retrieved from [https://www.imf.org/external/datamapper/NGDP\\_RPCH@WEO/OEMDC/ADVEC/WEO/WORLD](https://www.imf.org/external/datamapper/NGDP_RPCH@WEO/OEMDC/ADVEC/WEO/WORLD)
- Jackson, T. (2016). *Prosperity without growth: Foundations for the economy of tomorrow*. Abingdon: Routledge.
- Jackson, T., & Senker, P. (2011). Prosperity without growth: Economics for a finite planet. *Energy & Environment*, 22(7), 1013–1016. <https://doi.org/10.1260/0958-305x.22.7.1013>
- Jackson, T., & Victor, P. A. (2015). Does credit create a “growth imperative”? A quasi-stationary economy with interest-bearing debt. *Ecological Economics*, 120, 32–48. <https://doi.org/10.1016/j.ecolecon.2015.09.009>
- Kallis, G. (2018). *Degrowth*. Newcastle upon Tyne: Agenda publishing.
- Kellenberg, D. (2015). The economics of the international trade of waste. *Annual Review of Resource Economics*, 7, 109–125. <https://doi.org/10.1146/annurev-resource-100913-012639>
- King, M. (2019). *The world turned upside down: Economic policy in turbulent times*. The per Jacobsson lecture. Retrieved from [www.perjacobsson.org](http://www.perjacobsson.org)
- Krausmann, F., Gingrich, S., Eisenmenger, N., Erb, K.-H., Haberl, H., & Fischer-Kowalski, M. (2009). Growth in global materials use, GDP and population during the 20th century. *Ecological Economics*, 68(10), 2696–2705. <http://dx.doi.org/10.1016/j.ecolecon.2009.05.007>
- Kuznets, S. (1955). Economic growth and income inequality. *The American Economic Review*, 45(1), 1–28.
- Lagarde, C. (2014). *The challenge facing the global economy: New momentum to overcome a new Mediocre*. Retrieved from <http://www.imf.org/external/np/speeches/2014/100214.htm>
- Lekakis, J. N., & Kousis, M. (2013). Economic crisis, troika and the environment in Greece. *South European Society and Politics*, 18(3), 305–331. <https://doi.org/10.1080/13608746.2013.799731>
- Lewis, E., MacSharry, B., Juffe-Bignoli, D., Harris, N., Burrows, G., Kingston, N., & Burgess, N. D. (2019). Dynamics in the global protected-area estate since 2004. *Conservation Biology*, 33(3), 570–579. <https://doi.org/10.1111/cobi.13056>
- Marques, A., Martins, I. S., Kastner, T., Plutzer, C., Theurl, M. C., Eisenmenger, N., ... Pereira, H. M. (2019). Increasing impacts of land use on biodiversity and carbon sequestration driven by population and economic growth. *Nature Ecology and Evolution*, 3(4), 628–637. <https://doi.org/10.1038/s41559-019-0824-3>

- Martínez-Alier, J., Pascual, U., Vivien, F.-D., & Zaccai, E. (2010). Sustainable de-growth: Mapping the context, criticisms and future prospects of an emergent paradigm. *Ecological Economics*, 69(9), 1741–1747. <http://dx.doi.org/10.1016/j.ecolecon.2010.04.017>
- Mascia, M. B., Pailler, S., Krithivasan, R., Roshchanka, V., Burns, D., Mlotha, M. C. J., ... Peng, N. (2014). Protected area downgrading, downsizing, and degazettement (PADDD) in Africa, Asia, and Latin America and the Caribbean, 1900–2010. *Biological Conservation*, 169 (2014), 355–361. <https://doi.org/10.1016/j.biocon.2013.11.021>
- McClanahan, T. R. (2019). Coral reef fish communities, diversity, and their fisheries and biodiversity status in East Africa. *Marine Ecology Progress Series*, 632, 175–191. <https://doi.org/10.3354/meps13153>
- McClanahan, T. R., Schroeder, R. E., Friedlander, A. M., Vigliola, L., Wantiez, L., Caselle, J. E., ... Cinner, J. E. (2019). Global baselines and benchmarks for fish biomass: comparing remote reefs and fisheries closures. *Marine Ecology Progress Series*, 612, 167–192. <http://dx.doi.org/10.3354/meps12874>
- McPherson, M. A., & Nieswiadomy, M. L. (2005). Environmental Kuznets curve: Threatened species and spatial effects. *Ecological Economics*, 55(3), 395–407. <https://doi.org/10.1016/j.ecolecon.2004.12.004>
- Mills, J. H., & Waite, T. A. (2009). Economic prosperity, biodiversity conservation, and the environmental Kuznets curve. *Ecological Economics*, 68(7), 2087–2095. <https://doi.org/10.1016/j.ecolecon.2009.01.017>
- Monteiro, A., Russo, M., Gama, C., Lopes, M., & Borrego, C. (2018). How economic crisis influence air quality over Portugal (Lisbon and Porto)? *Atmospheric Pollution Research*, 9(3), 439–445. <http://dx.doi.org/10.1016/j.apr.2017.11.009>
- Nature Editorial. (2020). Include the true value of nature when rebuilding economies after coronavirus. *Nature*, 581, 119. <https://doi.org/10.1038/d41586-020-01390-w>
- OECD. (2008). Environmental outlook, annual report 2008. *EPPO Bulletin*, 39, 522–530. <https://doi.org/10.1111/j.1365-2338.2009.02340.x>
- Pacca, L., Antonarakis, A., Schröder, P., & Antoniadis, A. (2020). The effect of financial crises on air pollutant emissions: An assessment of the short vs. medium-term effects. *Science of The Total Environment*, 698, 133614. <http://dx.doi.org/10.1016/j.scitotenv.2019.133614>
- Pack, S. M., Ferreira, M. N., Krithivasan, R., Murrow, J., Bernard, E., & Mascia, M. B. (2016). Protected area downgrading, downsizing, and Degazettement (PADDD) in the Amazon. *Biological Conservation*, 197, 32–39. <https://doi.org/10.1016/j.biocon.2016.02.004>
- Pérez-Hoyos, A., Rembold, F., Kerdiles, H., & Gallego, J. (2017). Comparison of global land cover datasets for cropland monitoring. *Remote Sensing*, 9(11), 1118. <http://dx.doi.org/10.3390/rs9111118>
- Pheakey, H. (2013). *Chinese investment and aid in Cambodia a controversial affair*. East Asia Forum.
- Roodman, D. (2009). How to do xtabond2: An introduction to difference and system GMM in Stata. *Stata Journal*, 9(1), 86–136. <https://doi.org/10.1177/1536867x0900900106>
- Saffari, A., Daher, N., Samara, C., Voutsas, D., Kouras, A., Manoli, E., ... Sioutas, C. (2013). Increased biomass burning due to the economic crisis in Greece and its adverse impact on wintertime air quality in Thessaloniki. *Environmental Science and Technology*, 47(23), 13313–13320. <https://doi.org/10.1021/es403847h>
- Sanborn, C., & Chonn, V. (2015). *Chinese investment in Peru's mining industry: Blessing or curse?* Global Economic Governance Initiative. pp. 1–57.
- Santamouris, M., Paravantis, J. A., Founda, D., Kolokotsa, D., Michalakakou, P., Papadopoulos, A. M., ... Servou, E. (2013). Financial crisis and energy consumption: A household survey in Greece. *Energy and Buildings*, 65, 477–487. <http://doi.org/10.1016/j.enbuild.2013.06.024>
- Schneider, F., Kallis, G., & Martínez-Alier, J. (2010). Crisis or opportunity? Economic degrowth for social equity and ecological sustainability. Introduction to this special issue. *Journal of Cleaner Production*, 18(6), 511–518. <https://doi.org/10.1016/j.jclepro.2010.01.014>
- Shen, X. (2013). *Private Chinese investment in Africa: Myths and realities*. Washington, D.C.: The World Bank.
- Siddiqi, T. A. (2000). The Asian financial crisis—Is it good for the global environment? *Global Environmental Change*, 10(1), 1–7.
- Spash, C., & Schandl, H. (2009). Growth, the environment and keynes: Reflections on two heterodox schools of thought. *Socio-Economics and the Environment in Discussion (SEED) Working Paper Series*, CSIRO Sustainable Ecosystems. January, <https://EconPapers.repec.org/RePEc:cse:wpaper:2009-01>.
- Steinbach, R. (2019). Growth in low-income countries: evolution, prospects, and policies. *World Bank Policy Research Working Paper No. 8949*, July, <https://ssrn.com/abstract=3430564>
- Stern, D. I. (2004). The rise and fall of the environmental Kuznets curve. *World Development*, 32(8), 1419–1439. <https://doi.org/10.1016/j.worlddev.2004.03.004>
- Stern, N. (2006). The economics of climate change. *World Economics*, 7(2), 465–475.
- Suh, R. (2019, March). *We can't assume our water is safe to drink. But we can fix it*. National Geographic. Retrieved from <https://www.nationalgeographic.com/magazine/2019/03/drinking-water-safety-in-united-states-can-be-fixed/>
- Summers, L. H. (2015). Demand side secular stagnation. *The American Economic Review: Papers & Proceedings*, 105(5), 60–67.
- The World Bank (2020a). *Open data portal*. Retrieved from <https://data.worldbank.org>
- The World Bank (2020b). *World development indicators*. Retrieved from <https://datacatalog.worldbank.org/dataset/world-development-indicators>
- UNEP (2011). In M. Fischer-Kowalski, M. Swilling, E. U. von Weizsäcker, Y. Ren, Y. Moriguchi, & W., K. Crane (Eds.), *Decoupling natural resource use and environmental impacts from economic growth, a report of the working group on decoupling to the international resource panel*. Nairobi: United Nations Environment Programme.
- UNEP-WCMC. (2018). *Knowledge that makes a world of difference*. UNEP-WCMC Annual Review. Retrieved from [https://www.unep-wcmc.org/system/dataset\\_file\\_fields/files/000/000/559/original/UNEP\\_WCMC\\_ANNUAL\\_REVIEW\\_2017-18\\_revised\\_-\\_low\\_res\\_spreads.pdf?1542036626](https://www.unep-wcmc.org/system/dataset_file_fields/files/000/000/559/original/UNEP_WCMC_ANNUAL_REVIEW_2017-18_revised_-_low_res_spreads.pdf?1542036626)
- United Nation. (2020). *UN Data: A world of information*. Retrieved from <http://data.un.org/Default.aspx>
- USDA PS&D. (2020). *World food dataset*. Retrieved from <https://apps.fas.usda.gov/psdonline/app/index.html#/app/downloads>
- Vaden, T., Lähde, V., Majava, A., Järvensivu, P., Toivanen, T., Hakala, E., & Eronen, J. T. (2020). Decoupling for ecological sustainability: A categorisation and review of research literature. *Environmental Science and Policy*, 112, 236–244. <https://doi.org/10.1016/j.envsci.2020.06.016>
- van Beek, C. L., Meerburg, B. G., Schils, R. L. M., Verhagen, J., & Kuikman, P. J. (2010). Feeding the world's increasing population while limiting climate change impacts: Linking N<sub>2</sub>O and CH<sub>4</sub> emissions from agriculture to population growth. *Environmental Science and Policy*, 13 (2), 89–96. <https://doi.org/10.1016/j.envsci.2009.11.001>
- Van den Bergh, J. C. J. M. (2011). Environment versus growth—a criticism of “degrowth” and a plea for “a-growth”. *Ecological Economics*, 70(5), 881–890. <https://doi.org/10.1016/j.ecolecon.2010.09.035>
- Victor, P. A. (2012). Growth, degrowth and climate change: A scenario analysis. *Ecological Economics*, 84, 206–212. <https://doi.org/10.1016/j.ecolecon.2011.04.013>
- Ward, J. D., Sutton, P. C., Werner, A. D., Costanza, R., Mohr, S. H., & Simmons, C. T. (2016). Is decoupling GDP growth from environmental impact possible? *PLoS One*, 11(10), 1–14. <https://doi.org/10.1371/journal.pone.0164733>
- Wendling, Z. A., Emerson, J. W., de Sherbinin, A., Esty, D. C., et al. (2020). *2020 Environmental Performance Index*. New Haven, CT: Yale Center for Environmental Law & Policy. [epi.yale.edu](http://epi.yale.edu)
- Wiedmann, T. O., Schandl, H., Lenzen, M., Moran, D., Suh, S., West, J., & Kanemoto, K. (2015). The material footprint of nations. *Proceedings of the National Academy of Sciences of the United States of America*, 112(20), 6271–6276. <https://doi.org/10.1073/pnas.1220362110>

WWF (2019). *Protecting our ocean: Europe's challenge to meet the 2020 deadlines*. Brussels, Belgium. Retrieved from <https://www.bbc.co.uk/news/world-africa-46017359>

Yeh, E. T. (2016). Introduction: The geoeconomics and geopolitics of Chinese development and investment in Asia. *Eurasian Geography and Economics*, 57(3), 275–285. <https://doi.org/10.1080/15387216.2016.1237881>

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## APPENDIX A.

**TABLE A1** Real GDP growth (%)

Period	World	G7	G20 emerging	China	United States
1980–1989	3.15	3	3.91	9.75	3.13
1990–1999	3.1	2.5	3.79	9.98	3.23
2000–2007	4.34	2.31	4.97	10.04	2.84
2008–2019	3.55	1.3	3.67	8.45	1.7

Source: IMF (2020).

## APPENDIX B.

**TABLE B1** List of control variables

Dependent variable	Controlling variables
Terrestrial protected areas; Forest loss	GDP (constant 2010 US\$) (log) Foreign direct investment, net inflows (% of GDP) Employment in agriculture (% of total employment) Central government debt (% GDP) Employment in industry (% of total employment) Rural population (log)
Marine protected areas; fish stock status; Species protection index; species habitat index; Unsafe drinking water; wastewater treatment	GDP (constant 2010 US\$) (log) Education index Employment in agriculture (% of total employment) Age dependency ratio (% of working-age population) Central government debt (% GDP)
Tree-covered areas; agricultural land	GDP per capita (constant 2010 US\$) (log) Agriculture, forestry, and fishing, value added (% of GDP) Rural population (log)
CO <sub>2</sub> emissions; CH <sub>4</sub> emissions; N <sub>2</sub> O emissions; PM <sub>2.5</sub> pollution	GDP (constant 2010 US\$) (log) Energy use (kg of oil equivalent per capita) (log) Total natural resources rents (% of GDP) Urban population (% of total population)

## APPENDIX C.

**TABLE C1** Description of biomes subgroups

Biome	Biogeographical regions
Polar	Tundra, boreal forests/taiga, Montane Grasslands & Shrublands.
Temperate	Temperate conifer forests, temperate broadleaf & mixed forests, temperate grasslands, Savannas & Shrublands, temperate broadleaf & mixed forests, Mediterranean forests, Woodlands & Scrub, Deserts & Xeric Shrublands.
Tropical	Tropical & subtropical moist broadleaf forests, tropical & subtropical dry broadleaf forests, Tropical & Subtropical Grasslands, Savannas & Shrub, tropical & subtropical coniferous forests, Flooded Grasslands & Savannas, and mangroves.

## APPENDIX D.

**TABLE D1** Summary statistics of the dependent variables

	Mean	SD	Min.	Max.
Terrestrial protected areas (global)	1.85	1.25	−8	3
Terrestrial protected areas (national)	1.85	1.26	−9	3
Species protection index	2.06	1.02	−6	3
Species habitat index	4.6	0.01	5	5
Marine protected areas	−0.86	2.7	−10	5
Fish stock status	2.01	1.38	0	5
Forest loss	8.1	3.62	0	16
Tree-covered areas	−0.04	3.26	−9	7
Agricultural land	−3.61	1	−8	−2
Agricultural land (CCI)	−0.31	3.19	−10	5
Unsafe drinking water	5.14	2.26	0	9
Wastewater treatment	3.79	1	0	5
CO <sub>2</sub> emissions	2.36	2.01	0	9
CH <sub>4</sub> emissions	2.14	1.57	0	7
N <sub>2</sub> O emissions	1.45	1.26	0	7
PM <sub>2.5</sub> pollution	3.18	0.57	2	5
Observations	12,754			

Note: Unsafe drinking water and PM<sub>2.5</sub> air pollution have been interpolated up to four consecutive years due to missing observations. All variables have been transformed into logarithmic form.

## APPENDIX E.

**Environmental indicators****Biodiversity indicators**

The environmental indicators adopted are listed in Table 2. Biodiversity indicators are taken from the The World Bank (2020b) database. *Terrestrial protected areas* measures the percent of a country's biomes in terrestrial protected areas, weighted by the prevalence of different biome types either around the world (Global) or within that country (National). *Species protection index* measures protected areas in relation to species distributions. The proportion of a species range in a country under protection is calculated for each species as area of species range in country protected divided by the area of species range in country and capped at a maximum of 0.17. *Species habitat index* measures changes in the suitable habitats of species to provide aggregate estimates of potential population losses and extinction risk increases. Each species is assessed separately, and the index is calculated as a weighted average of the habitat changes for each species with weights determined by the proportion of global range found in the country. *Fish stock* status measures the percentage of a country's total catch that come from taxa that are classified as either over-exploited or collapsed. This value is then averaged for all species occurring in a country, with all species weighted equally. *Marine protected areas* measure the percent of a country's Economic Exclusion Zone set aside as a marine protected area (Wendling et al., 2018).

**Agriculture indicators**

*Agricultural land*, in hectares, from the The World Bank (2020b) refers to the share of land area that is arable, under permanent crops, and under permanent pastures. Arable land includes land defined by the FAO as land under temporary crops (double-cropped areas are counted once), temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land temporarily fallow. Land abandoned as a result of shifting cultivation is excluded.

**Forest indicators**

*Tree cover loss* from the CCI, is defined as “stand replacement disturbance,” or the complete removal of tree cover canopy at the Landsat pixel scale, presented in hectares. In the Global Forest Watch (2020) database, tree cover is defined, in hectares, as all vegetation greater than 5 m in height and may take the form of natural forests or plantations across a range of canopy densities.

**Water indicators**

*Unsafe drinking water* measures the actual outcomes from lack of access or use of improved sources of drinking water. It measures unsafe drinking water using the number of age-standardized disability-adjusted life-years lost per 100,000 persons (DALY rate) due

to exposure to unsafe drinking water. Data for this indicator come from the Institute for Health Metrics & Evaluation's (IHME) Global Burden of Disease (GBD) study (EPI-Yale, 2020). *Wastewater treatment* comes from the United Nations (2020) and measures the percentage of population connected to a wastewater treatment plant through a public sewage network. This indicator does not take into account independent private facilities, used where public systems are not economic.

#### Atmospheric emissions indicators

The dataset comprises three greenhouse gas emissions: carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O). CO<sub>2</sub> emissions comprise emissions mostly from sources such as the consumption and production of fossil fuels, including coal, peat, petroleum, and natural

gas and the production of cement. CH<sub>4</sub> emissions are a major part of the global greenhouse gas emissions, encompassing emissions from agriculture, produced mostly by humans and livestock animals as well as natural sources such as wetlands. Also, to a minor extent, methane is produced from rice production and waste and from industrial activity. N<sub>2</sub>O emissions are produced mostly from the agricultural sector, especially the use of manure and nitrogen fertilizers (Davidson, 2009). N<sub>2</sub>O emissions are therefore not well correlated with CO<sub>2</sub> or CH<sub>4</sub> emissions as these have different sources. PM<sub>2.5</sub> air pollution measures the population-weighted exposure to ambient PM<sub>2.5</sub> pollution, defined as the average level of exposure of a nation's population to concentrations of suspended particles measuring less than 2.5 µm in aerodynamic diameter, which are capable of penetrating deep into the respiratory tract and causing severe health damage. Exposure is calculated by weighting mean annual concentrations of PM<sub>2.5</sub> by population in both urban and rural areas (The World Bank, 2020a).

## APPENDIX F.

TABLE F1 Robustness checks for the income subgroups

Dependent variable	GMM					GLS-fixed effects				
	(1) Global b (se)	(2) Low b (se)	(3) Lower mid b (se)	(4) Upper mid b (se)	(5) High b (se)	(6) Global b (se)	(7) Low b (se)	(8) Lower mid b (se)	(9) Upper mid b (se)	(10) High b (se)
Terrestrial protected areas (%EEZ- National Weights)	-0.014 (0.012)	-0.016 (0.015)	-0.028* (0.017)	-0.018* (0.010)	-0.020** (0.009)	-0.08012*** (0.016)	-0.06256 (0.040)	-0.08098** (0.038)	-0.10336*** (0.023)	-0.03998** (0.019)
Terrestrial protected areas (%EEZ-global weights)	-0.009 (0.011)	-0.027 (0.035)	-0.0388** (0.014)	-0.0158** (0.008)	-0.0175* (0.009)	-0.06399*** (0.015)	-0.02633 (0.034)	-0.07604** (0.037)	-0.08281*** (0.022)	-0.04348** (0.019)
Species protection index (% species)	-0.028** (0.012)	-0.008 (0.029)	-0.012* (0.006)	-0.017** (0.006)	-0.005 (0.011)	-0.02898** (0.012)	-0.02038 (0.023)	-0.03485** (0.015)	-0.04627** (0.016)	0.01455 (0.017)
Species habitat index (% habitat)	0.0007*** (0.000)	0.000 (0.000)	0.0009** (0.000)	0.0009*** (0.000)	0.0004** (0.000)	0.00006 (0.000)	-0.00017 (0.000)	-0.00013 (0.000)	0.00027* (0.000)	-0.00011 (0.000)
Fish stock status (% of catch)	-0.0860* (0.044)	-0.334 (1.314)	-0.018 (0.086)	-0.1446* (0.078)	-0.0692** (0.028)	-0.03646 (0.030)	0.043 (0.184)	-0.05915 (0.069)	-0.02921 (0.042)	-0.06061 (0.057)
Marine protected areas (unitless)	-0.2038** (0.080)	-0.029 (0.029)	-0.0900** (0.028)	-0.1007** (0.050)	-0.5627*** (0.162)	-0.21796 (0.221)	-0.15357 (0.140)	0.27912 (0.294)	-0.07804 (0.109)	-0.71451* (0.413)
Agricultural land (ha) (CCL_LC)	0.004* (0.002)	-0.002* (0.001)	0.016 (0.012)	-0.011* (0.006)	0.003** (0.001)	0.00034 (0.001)	0.00006 (0.001)	0.00392 (0.004)	-0.00440** (0.002)	0.00370** (0.001)
Agricultural land (ha) (WDI)	0.002 (0.004)	-0.0066* (0.004)	-0.0028* (0.002)	0.0070* (0.004)	-0.010 (0.016)	-0.00108 (0.002)	-0.00227 (0.002)	-0.00332** (0.002)	0.00266 (0.004)	-0.0027 (0.006)
Forest loss (ha)	-0.026 (0.039)	0.141 (0.266)	-0.247** (0.118)	-0.113 (0.072)	0.409*** (0.111)	-0.21827*** (0.045)	-0.34511** (0.141)	-0.18581** (0.084)	-0.10138 (0.074)	-0.26196* (0.083)
Tree-covered areas (ha)	-0.002* (0.001)	-0.003 (0.005)	-0.004* (0.002)	-0.002 (0.002)	-0.003** (0.001)	-0.00209*** (0.001)	-0.00391 (0.002)	-0.00217* (0.001)	-0.00064 (0.001)	-0.00265** (0.001)
Unsafe drinking water (% of population)	0.0061** (0.003)	0.002 (0.007)	0.002 (0.006)	0.009 (0.009)	-0.0186** (0.008)	-0.01341*** (0.002)	-0.01115 (0.008)	-0.01864*** (0.002)	-0.00363 (0.003)	-0.01381*** (0.002)
Wastewater treatment (% of population)	0.028 (0.070)	0.000 (.)	0.000 (.)	0.007 (0.041)	0.022 (0.024)	0.02219 (0.025)	0 (.)	-0.01423 (0.015)	-0.02424 (0.023)	0.05761 (0.040)
CO <sub>2</sub> emissions (MtCO <sub>2</sub> e-Total excluding LULUCF)	0.007 (0.007)	0.0696* (0.040)	-0.008 (0.017)	-0.032 (0.028)	-0.0251*** (0.007)	0.004 (0.005)	0.027 (0.021)	0.007 (0.014)	-0.008 (0.010)	-0.02837** (0.013)
N <sub>2</sub> O emissions (MtCO <sub>2</sub> e-Total excluding LULUCF)	0.0075 (0.006)	0.0220** (0.011)	-0.0048 (0.007)	-0.0172 (0.025)	0.0076 (0.013)	-0.0071 (0.004)	0.022 (0.020)	-0.00888 (0.007)	0.002 (0.011)	-0.00328 (0.006)
CH <sub>4</sub> emissions (MtCO <sub>2</sub> e-Total excluding LULUCF)	0.001 (0.005)	-0.020 (0.025)	-0.018 (0.014)	-0.0236* (0.013)	0.001 (0.003)	0.002 (0.004)	-0.015 (0.011)	-0.010 (0.009)	0.015 (0.010)	-0.01228* (0.006)
PM <sub>2.5</sub> pollution (micrograms per cubic meter)	-0.0315*** (0.003)	-0.042 (0.030)	-0.0185** (0.008)	-0.0458*** (0.007)	-0.0518*** (0.007)	-0.01601*** (0.002)	0.008 (0.006)	-0.00864** (0.004)	-0.01751*** (0.002)	-0.02022*** (0.002)

Note: The table reports estimate and robust standard errors underneath. The results from column (1) to (5) come from system two-step GMM specifications, with both the lagged dependent variable and the stagnation variable treated as endogenous and instrumented with its second lag or higher, while all the other variables are treated as exogenous. Column (6) to (10) come from the GLS specification with country and year fixed effects included in the regressions. All dependent variables are in logarithmic form. \* $p < 10\%$  is the significance level. \*\* $p < 5\%$  is the significance level. \*\*\* $p < 1\%$  is the significance level.